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TOBACCO MOSAIC-PROOFED WITH GLUTINOSA CHROMOSOMES
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Red-Eyed Swine

Sexing by Microscope

Designating Twins in Pedigrees

Growth Factors in Sorghum Hybrids

A Pedigree of Curved Forefingers

VOLUME 36 JULY, 1945 NUMBER 7

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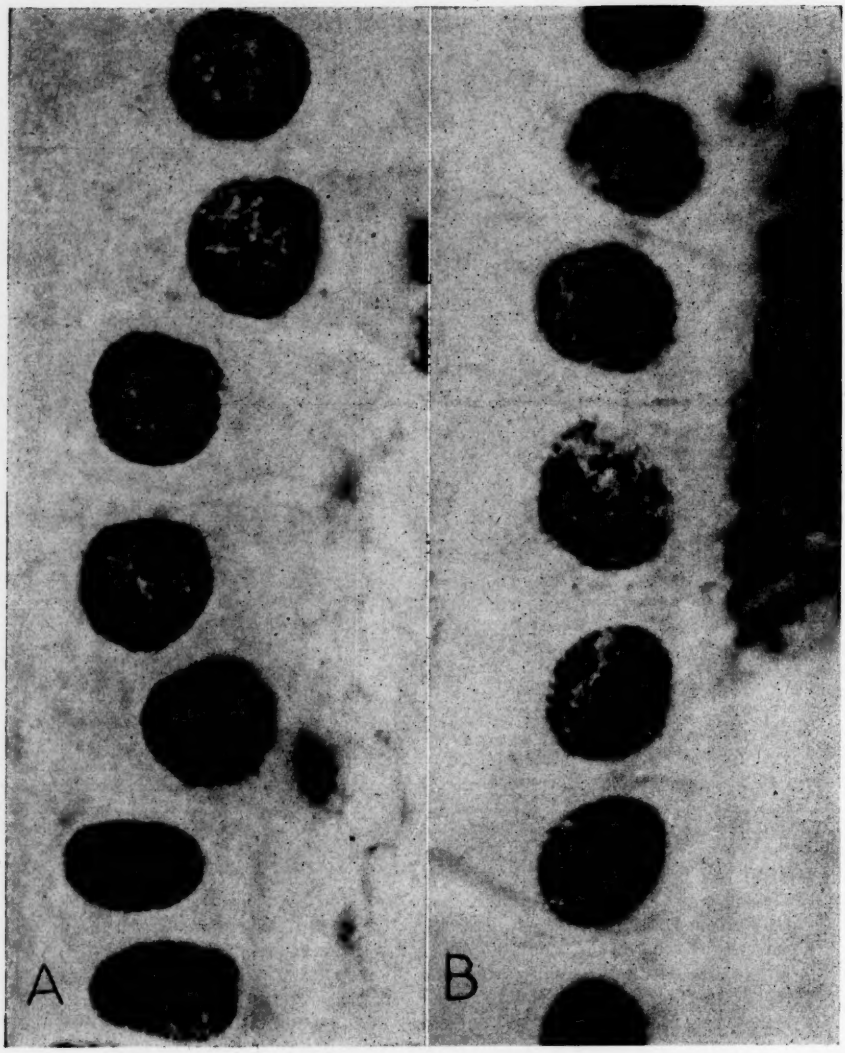

SEX IDENTIFICATION BY CHROMOSOME DIFFERENCES

Figure 1

In the early stages of the spruce budworm it is impossible to distinguish the sexes by morphological differences. These photomicrographs of the nuclei of the larval silk glands show how differences in the behavior of the sex chromosomes can be used to tell males and females apart. It is well known that in many organisms during the formation of germ cells the sex chromosomes exhibit heteropycnosis,—that is, they alone remain compact and take nuclear stains throughout the division cycle. In the spruce budworm the somatic cells exhibit this property. Thereby it is possible to distinguish the large sex chromosome in female cells shown at *A*. The nuclei of male silk gland cells (*B*) show no such darkly staining bodies. In this species, the sex identification through heteropycnosis makes possible a determination of the sex ratio at a far earlier stage of development than has been possible heretofore.

HETEROPYCNOSIS AS A MEANS OF DIAGNOSING SEX*

STANLEY G. SMITH†

EARLY in the course of cytogenetic studies‡ on the spruce budworm, *Archips* (*Cacoecia*) *fumiferana* (Lepidoptera), the need was felt for more detailed information regarding the sex ratio in this species. To date our knowledge of the proportions of the two sexes has been limited to the later stages owing to the fact that males and females are morphologically indistinguishable before the third larval instar. Prior to this stage, however, considerable mortality occurs and it has not been possible to determine whether it is differential in its action. Unless the sexes can be separated before mortality can play any appreciable part, an assessment of the relative mortality of the two sexes must be based on the assumption of numerical equality of gametes at fertilization. Obviously, as with other organisms (see review by Crew[1]), this is an assumption which is open to question.

In view of the well-known facts regarding heteropycnosis, the method of using this tendency of the *sex* chromosomes to remain compact and stainable during the resting stage suggested itself for diagnosing sex. Its use clearly hinges on whether or not the phenomenon expresses itself somatically. If it does, there is the obvious advantage that, although other cytological methods are theoretically possible, attention can then be confined to the resting nuclei, leaving the observer independent of numerical or size differences and angle of vision. The first step was to test for somatic heteropycnosis in larvae in which the sex could be predetermined by simple observation. Fortunately for such a project, the gonads of the male are clearly visible through the integument of the fourth and later larval instars. Feulgen "squash" preparations[4] and temporary aceto-carmine smears made from the intestine showed deeply-staining bodies in the resting nuclei of each of 17 female larvae studied, while they were absent from all 12 males examined. These heteropycnotic bodies, restricted to the nuclei of females, obviously are the sex chromosomes and may therefore be used in the diagnosis of sex.

The method, slightly modified, was then applied to 399 freshly eclosed progeny of eight budworm pairs collected *in copula* from the wild. The modification was called for on account of the small size of the larvae and the large numbers being dealt with. It consisted in fixing, embedding and sectioning families *en masse*, rather than making individual preparations. Diagnosis in the sectioned material could again be based on conditions in the nuclei of the intestine (and other organs and tissues), but it was found in practice far simpler to examine the especially large cells of the silk glands (see Figure 1) since their use did away with the necessity of using the oil immersion objective. The results are tabulated in Table I.

There is, of course, need for considerable amplification before much significance can be attached to the ratio determined by this method. But what is shown is that heteropycnosis can be used in the diagnosis of sex when, as in the present case, it is a property of the somatic chromosomes of a species. By the use of this method direct evidence

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‡The studies mentioned here form a part of the broader investigations into the biology of the spruce budworm which were initiated in 1937 in connection with the current outbreak now extending over a large area of the coniferous forests of northeast North America.

can be obtained on the part played by genetic and other factors in modifying the secondary sex ratio, since, by summating the data obtained from mortality-free egg clusters, a definite evaluation of the primary sex ratio is possible.

To what extent the method is applicable to other organisms remains to be determined. The limiting factor resides in the organism itself: the manifestation of heteropycnosis is extremely variable (see review by Schrader[3]). Its expression, even in closely related species, is constant as to neither time nor sex.[2] The method promises, however, to shed light on certain of the problems posed by mammalian sex ratios: as has long been recognized, the female heterogamy of Lepidoptera constitutes the natural experiment by means of which a variety of hypotheses can be critically appraised.

Summary

The possibility is demonstrated of using somatic heteropycnosis as diagnostic of sex prior to sexual differentiation and before differential mortality can distort the primary sex ratio.

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2. Geitler, L. *Chromosoma* 1(2) :197-229. 1939.
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TABLE I. Analysis of Heteropycnosis in Budworm Larvae

Family number	Total eggs laid	Total eggs unhatched	Percentage mortality	Heteropycnosis Without	Heteropycnosis With	Sex ratio ♂	Sex ratio ♀
8	53	0	0	25	28	89	100
7	64	2	3	28	34	82	100
10	90	8	9	35	47	74	100
6	49	8	16	18	19	95	100
13	98	19	19	35	37	95	100
1	34	9	26	5	20	25	100
21	67	25	37	22	16	137	100
14	83	53	64	5	25	20	100
	538	124	23	173	226	76	100
			Expected	199.5	199.5		

$\chi^2 = 7.04$; $P = ca\ .01$

✦

The Nature-Nurture Matrix

Non-geneticists may feel disinclined to regard as hereditary a trait so plastic that it appears in some environments but not in others. Yet, all degrees of environmental plasticity occur. For example, the *A–a'B–a* blood group genes produce the same "character" in all known environments. The outward manifestations of the genes for eye color slightly changes with age. The environmental dependence of stature, weight and skin color is obvious. Behavior is influenced so much by environmental variables, particularly training, social conditions and accumulated experience, that the genetic variable is frequently masked. The designation "hereditary" can not be restricted to traits which show a certain degree of constancy of expression. The degree of constancy is itself inconstant; introduction of insulin treatments made the expression of the genes for diabetes much more labile than it was. It may seem trite to remind that genes influence the development through chains of physiological reactions. The possibilities of controlling the gene manifestation will be greatly increased when these reactions become known. Theoretically, the action of any gene may be controlled. To say that man's psychology is inherited does not, by any stretch of imagination, mean that it is fixed and unalterable. We can not change our heredity directly, but heredity is not implacable destiny to which one must submit in resignation. We should seek for ourselves and contrive for others, environments in which our heredities respond most favorably. If the genotypes of all men responded to every given environment by producing the same "psychology," we could say that psychic characters are not inherited. This, I take it, is not contended even by most confirmed environmentalists.—Th. Dobzhansky in *Amer. Biol. Teacher*, Mar., 1945.

INHERITANCE IN NICOTIANA TABACUM

XX. The Addition of *Nicotiana glutinosa* Chromosomes to Tobacco

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GENETICISTS and breeders will focus their attention more and more upon ways and means to overcome genetic barriers between species, which hinder the utilization of genetic material derived from interspecific hybridization.

"Alien substitution races" (Gerstel[5]) may deserve consideration in this connection. In these, a pair of chromosomes from one species is substituted for a pair from another one. Kattermann[9,10] has produced a strain of wheat with twenty pairs of wheat and one pair of rye chromosomes. Holmes[8] succeeded in transferring resistance to mosaic disease from *Nicotiana glutinosa* to *N. tabacum* by replacing the *Tabacum* chromosomes designated by the letter "H" by a pair from *N. glutinosa*, as shown by Gerstel.[4,5]

This method of substitution of chromosomes makes possible the transfer of genetic factors from one species to another in interspecific hybrids where the common breeding methods fail because of lack of meiotic pairing and crossing over. The same end may also be served by the addition of chromosomes to a complement. Thus Florell[3] and O'Mara[17] added single pairs of rye chromosomes to wheat, and Upland cotton plants with an extra pair of chromosomes were derived from species hybrids by Beasley and Brown.[1]

Such types having an unaltered complement of one species and added pairs of chromosomes from another will be called *alien addition races*, as proposed by Professor R. E. Clausen. The present contribution is a study of the origin and behavior of alien addition races in *N. Tabacum*.

Materials and Methods

The inbred Purpurea variety of *N. Tabacum* L. (n = 24, Figure 3*A* and 5*A*) and a subarborescent type of *N. glutinosa* L. (n = 12, Figure 4) from Lima, Peru, were used in these experiments.

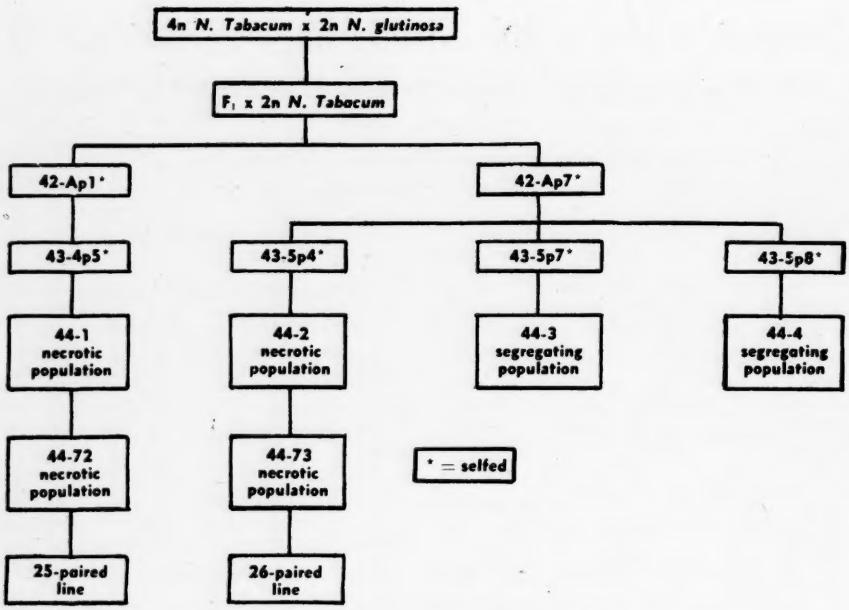
Tetraploid tobacco plants were obtained by submerging seedlings at the time of emergence in .1 per cent aqueous colchicine solution for three hours.

Tests for mosaic resistance were made by inoculating either potted plants or excised leaves in a moist chamber as described previously by the author.[4] The inoculum consisted of juice from tobacco plants infected with the common tobacco mosaic disease. "Resistance" of *N. glutinosa* is due to a localization of the particles of the mosaic virus in necrotic lesions; the leaves of susceptible tobacco plants become mottled and distorted after infection in the field or greenhouse. The two types of reaction are usually called "mottling" and "necrotic." Excised leaves of the necrotic type show the typical lesions after inoculation, while those from susceptible plants produce no symptoms.

All counts of chromosome numbers were made from first metaphases of pollen mother cells smeared in aceto-orcein. Micronuclei and microcytes were counted in similar preparations from slightly older anthers with PMC's (pollen mother cells) in the tetrad stage.

Fertility was determined from pollen smeared in a mixture of lactophenol and fuchsin; it was assumed that the pro-

*The author wishes to thank Professor R. E. Clausen for his helpful discussions and criticism during the execution of the present study. He is indebted to Professor E. B. Babcock and to Professor G. L. Stebbins, Jr., for many valuable suggestions and for careful reading of the manuscript.



ORIGIN OF THE EXTRA CHROMOSOME STRAINS

Figure 2

This chart shows how the strains of tobacco having one pair of chromosomes from the mosaic resistant species, *Nicotiana glutinosa,* were produced. By introducing a pair of alien chromosomes it has proved to be possible to transfer a desired characteristic from one species into another species having all of the other agronomic advantages desired by the breeder.

portion of normal sized grains represented a measure of relative fertility.

Results

Alien addition types were obtained by first pollinating a 60-chromosome hybrid between tetraploid *N. Tabacum* ($2n = 96$)* and diploid *N. glutinosa* ($2n = 24$) with pollen from diploid tobacco. The resulting progeny exhibited a great degree of variation in vigor, presumably because of the segregation of highly unbalanced chromosomal types with varying numbers of univalent *glutinosa* chromosomes.

Two plants from this progeny, which exhibited the necrotic reaction and had five and seven extra chromosomes respectively, were self-pollinated. Four vigorous plants from among their offspring, one from one and three from the other parent, were selfed in turn. The four progenies were planted in the greenhouse; two of them were found to consist only of necrotic type plants, while two segregated necrotic and mottling types. The derivation of these four progenies is outlined in Figure 2.

A population of plants with 25 pairs of chromosomes. Cytological examination of ten plants of population 44-1 showed that they all — with one exception — had 25 pairs of chromosomes (Table I). Some had an additional univalent. The exceptional plant had 24 pairs and two univalents. Smears made

*Tetraploid tobacco actually is an octoploid, considering the origin of *N. Tabacum;* and a hybrid between tetraploid tobacco and a species having the basic chromosome number, as *N. glutinosa,* is therefore pentaploid.

NORMAL TOBACCO AND EXTRA CHROMOSOME STRAINS

Figure 3

A—Plant of normal tobacco (*Nicotiana Tabacum*) of the Purpurea variety. *B* shows the 25-paired race with one pair of *glutinosa* chromosomes; and *C* shows the race with two pairs of the alien chromosomes—26 pairs of chromosomes in all. Both of these races are resistant to mosaic and fairly true-breeding.

from the still available parent plant revealed that it had 25 pairs and one univalent.

Population 44-1 appeared uniform. The flowers were of about normal length, but the corolla limbs were wider and had deeper sinuses than those of the Purpurea type (Table II). No attention was paid at the time to vegetative characteristics, but selfed offspring were raised in the field in the following summer and plant habit and foliage were studied. Figures 3*A* and *B* show habit photographs of normal and 25-paired plants. Greater compactness of the inflorescences and shorter internodes were evident in the latter. The 25-paired plants were also slightly reduced in overall length and were later maturing than normal plants set out at the same time.

A population with 26 pairs of chromosomes. Pollen mother cells of ten plants of population 44-2 were studied. Of these eight had 26 pairs while two had an additional univalent (Table I). This population also appeared to be uniform. Flowers were considerably smaller than in the normal type (Table II). The color of the corolla of greenhouse-grown plants was pink and very distinct from the normal carmine. However, the flower color of plants grown in the field and exposed to the sunlight could not be distinguished from the normal. Figure 5 shows a flower of this type together with the 25-paired and the normal types. Field-grown plants were con-

siderably shorter than normal plants and flowered later (Figure 3*C*). Internodes were reduced in length, the leaves shorter, but proportionately wider and thicker. Inflorescences were still more crowded than in the 25-paired plants.

Fertility. The 25- and 26-paired types may be presumed to represent the addition types announced in the introduction and to have one or two *glutinosa* pairs in addition to the *Tabacum* complement. Their fertility can be considered good, even though the rate of pollen abortion seems to be slightly higher than in the normal type (Table II). No comparative seed counts were made, but the capsules were filled with seed that germinated well. Percentages of seed germination were high, namely 98.0 ± 2.0 per cent for the 25-paired and 95.9 ± 2.8 per cent for the 26-paired types.

Cytological behavior. The degree of stability of the addition races is of particular interest, as this is one of the factors limiting the usefulness of such types to the breeder. Twenty-five metaphases of one plant of each type were counted (Table III); and some non-conjunction or early disjunction was observed, namely two cases in the 25- and three in the 26-paired plants. It was not possible to decide whether an added *glutinosa* or a *tabacum* pair was behaving irregularly in these cases because of the similarity of *glutinosa* and *Tabacum* chromosomes. Olmo[16] in a study of meiotic irregularities in the Purpurea variety and its monosomics found complete regularity in pairing in twenty-two cells of the normal, but Clausen (unpublished) has seen univalents in the normal type.

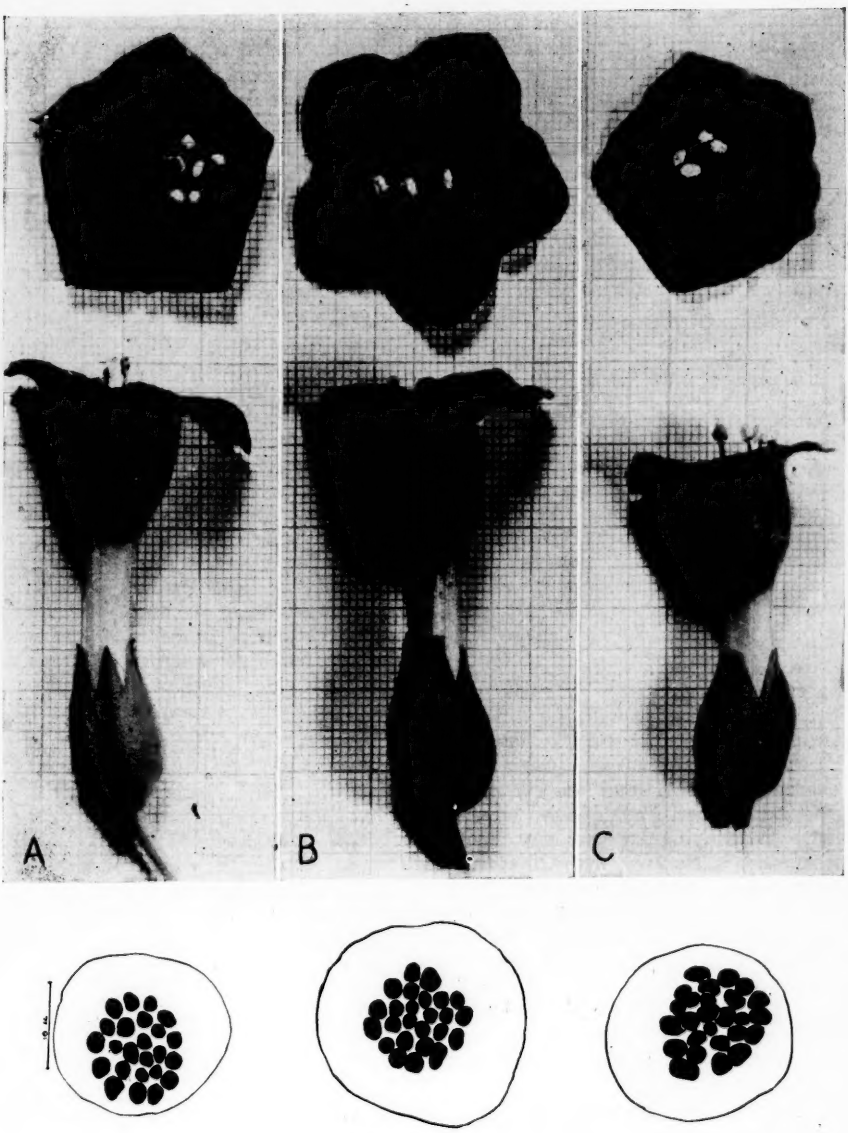
Tetrad studies. Meiotic irregularity was also measured in terms of the degree of elimination in pollen tetrads. For this purpose the tetrads showing one or more micronuclei or microcytes were counted and their proportion from the total calculated. Micronuclei are formed from unassociated chromosomes which are excluded from the groups going to either spindle pole. They may become microcytes after cell wall formation.

Olmo[15] has shown that about 66 per cent of the pollen mother cells of monosomics eliminate one or both chromatids of the monosome. He found this percentage of tetrads with one or more microcytes in several different monosomic types. Similar values were obtained by the writer for univalent elimination in a $25_{II} + 1_I$ plant and also in one with $26_{II} + 1_I$ (Table IV). Therefore the amount of univalent elimination is a constant and is independent of the cytogenetic constitution in this material.

The addition types showed slightly but not significantly higher values for elimination than the normal type as determined by Olmo.[16] These frequencies are listed in Table IV. It is of interest to compare these values with the observed frequencies of occurrence of nonconjugating metaphasic pairs (Table III). Thus for the 25-paired type the

THE GLUTINOSA PARENT
Figure 4

Greenhouse-grown plant of *Nicotiana glutinosa* (Lima strain). This plant is mature and in flower. Compared with tobacco it is a dwarf and its chief importance is complete resistance to tobacco mosaic disease.



FLOWERS AND CHROMOSOMES

Figure 5

Flowers and camera lucida drawings of first meiotic metaphase of normal Purpurea tobacco (*A*), 28-paired race (*B*), and 26-paired race (*C*). The flowers are slightly enlarged (the background scale is in milimeters). One of the extra chromosomes conditions resistance to mosaic and the other affects stature and growth habits. It may be that the differences are due to genes resident on these specific chromosomes rather than to a difference in nuclear volume.

number of metaphase cells with non-conjugating pairs would be expected to lie between 5.7 per cent and $5.7/65.7 \times 100 = 8.7$ per cent on the basis of microcyte counts. For the 26-paired plants this value should lie between 6.7 per cent and 10.2 per cent. In both cases the expected values check reasonably well with the observed ones, the latter being 8.7 ± 1.8 and 13.6 ± 2.8 per cent respectively (Table III).

Cytogenetic tests. Three selfed generations of both the 25-paired and the 26-paired lines were grown and the offspring classified into parental and aberrant classes. Also plants of each line were backcrossed to normal and the proportion of unexpected types tabulated. The expected types were plants with 24 bivalents and one or two univalents for backcrosses from the 25- and 26-paired lines respectively.

The results are shown in Table V. Three non-parental offspring were obtained from selfing plants with 25 pairs. A plant with $24_{II} + 2_I$ from this cross was mentioned above. It was of the necrotic type and therefore had the same *glutinosa* chromosome as its sibs, but as a single. In addition this plant probably carried the other *glutinosa* chromosome present in the parent (43-4p5). One of the contributing parental gametes may be assumed to have been deficient for a necrosis-carrying chromosome.

Two aberrant plants in the next selfed generation in all likelihood were also lacking this *glutinosa* chromosome. This population appeared uniform in the field, except for two plants which had a looser inflorescence and looked like the trisomic type. Pollen mother cells of one of them showed $24_{II} + 1_I$.

Among the plants resulting from the backcrosses of the 25-paired type to normal one plant was normal in appearance and one was teratological. The rest were trisomics.

No irregularities at all were observed in the selfed and backcrossed populations from the 26-paired line.

All these plants were classified on a morphological basis and a few plants of the "expected" type in each case were studied cytologically as a check. The 25- and 26-paired plants are distinctive types, as described above. The two trisomic plants ($24_{II} + 1_I$) occurring in the 25-paired population were easily recognized. However, it was difficult to spot normal plants in the trisomic populations from the cross $25_{II} \times 24_{II}$. One plant could be classified with some certainty by its morphology as normal. It was expected that normal and trisomic plants could also be distinguished by their mosaic reaction, but mosaic tests in the moist chamber proved to give no results in the populations from this particular cross. It was found that excised leaves with one necrosis-bearing *glutinosa* chromosome in the presence of the complete diploid *Tabacum* complement do not react with definite necrotic spots upon inoculation, though inoculated whole plants of the same type isolate the virus in typical localized lesions. No tests were made in the field. Pollen counts also failed to distinguish between normal and trisomic types (Table VI).

Table I. Cytological constitution of ten plants of each addition population.

Population number	Chromosomal type of parent	Valencies				
		$24_{II} + 2_I$	25_{II}	$25_{II} + 1_I$	26_{II}	$26_{II} + 1_I$
44-1	$25_{II} + 1_I$	1*	6	3	-	-
44-2	$26_{II} + 2_I$	-	-	-	8	2

* no cells with 25_{II} were observed in this plant.

Table II. Comparison between the addition products and normal Purpurea. (Greenhouse plants).

Population number	Number of pairs	Fertility		Corolla length mm	Limb width mm	Population size
		Capsules	Percent aborted pollen*			
44-1	25	well filled	13.9 ± 1.3	45.7 ± .3†	30.4 ± .4†	22
44-2	26	well filled	15.6 ± 1.5	37.3 ± .2†	25.6 ± .5†	18
Purpurea	24	well filled	9.2 ± 1.2	47.6 ± .3†	28.0 ± .3†	--

* Percentages of aborted grains were obtained from about 500 grains from a single, vigorous plant in each case.

† Means from all mature plants in the population.

‡ Mean from ten flowers of a single plant.

Table III. Meiotic configurations in twenty-five PMC's of the addition races.

Plant number	Configurations				Percent of cells with non-conjunctive pair
	$24_{II} + 2_I$	25_{II}	$25_{II} + 1_I$	26_{II}	
44 1p4	2	23	-	-	8.7 ± 1.8
44 2p9	-	--	3	22	13.6 ± 2.8

Table IV. Chromosome elimination in tetrads.

Type	Tetrads observed	Percent showing elimination
25 II	300	5.7 ± 1.3
26 II	300	6.7 ± 1.7
24 II (Olme, 1936)	534	4.1 ± .82
25 II - 1 I (Olme, 1936)	2488	65.7 ± .95*
25 II - 1 I	100	68.0 ± 4.7
26 II - 1 I	100	63.0 ± 4.8

* Data lumped from four different monosomics which showed homogeneous frequencies for elimination

Therefore the data presented for the backcrosses from the 25-paired line should be evaluated with some caution.

As stated, no irregularities at all were observed in the offspring from the 26-paired plants. Aberrant plants should be easily detected by morphological criteria such as flower length (Table VI), because the types with zero, one or two doses of the 26th chromosome are very distinct. Only "expected" types were observed in the selfed or backcrossed populations. Therefore the 26th pair, consisting of the *glutinosa* chromosomes reducing flower size, was disjoining regularly in all instances. Whether the 25th pair, carrying the necrosis factor, was also stable in these populations, could not be judged, as it was not decided whether the 26th chromosome masks absence of the 25th.

In summarizing it may be stated that there were four or five among a total of 129 selfed or backcrossed plants which were found to have less than the expected one or two necrotic chromosomes, as the case may be. No deficiencies for the 26th, the flower-shortening chromosome, could be identified.

Discussion

The first prerequisite for the production of addition races is some degree of fertility of the amphidiploid and its triploid (or pentaploid in this case) derivatives. Dominance of the marker gene should also be counted among the necessary requirements. Though addition products could be recognized by cytological means, their value for the breeder lies in the substitution of a desirable character for an undesirable one.

Chromosome pairs may be added to a complement by the union in a zygote of extra homologues carried in both gametes, provided the extra chromosome is transmitted through the pollen. The addition could also be brought about by an inclusion of both chromatids of an extra univalent in one of the gametes. While the latter mechanism would result in the addition of an identical pair of chromosomes, some heterozygosity may be the consequence of the former.

TABLE V. Offspring from the 25-paired and 26-paired lines.

Population number	Seeds sown	Mature plants of expected types	Aberrants
		— SELFINGS —	
43 4p5	Parent plant of 25 II line		(with $25_{II} + 1_I$)
44 1	30	22*	1 ($24_{II} + 2_I$)
44 72	49	36	2 ($24_{II} + 1_I$)
43 5p4	Parent plant of 26 II line		(chromos. no. not det.)
44 2	30	15*	–
44 73	49	24	–
		— BACKCROSSES TO NORMAL (24 II) —	
		25 II × Normal	
44 63 (43 4p5 × norm.)	50	33*†	1 (normal) 1 (teratological)
44 76 (44 1p4 × norm.)	50	38†	–
		26 II × Normal	
44 64 (44 5p4 × norm.)	50	33*	–
44 75 (44 2p7 × norm.)	50	34	–

* Some of these plants had the extra univalent present in the 43 4p5 and 43 5p4 parents.
† These trisomics were difficult to distinguish from normal and some normal plants may have been overlooked.

TABLE VI. The addition types and their hybrids: Pollen abortion and flower length of field grown plants.

Type	Pollen abortion %	Flower length range in mm.
24_{II}	9.2 ± 1.2	47 - 52
$24_{II} + 1_I$ ($25_{II} \times 24_{II}$)	6.4 ± 1.0	47 - 51
$24_{II} + 2_I$ ($26_{II} \times 24_{II}$)	11.8 ± 1.4	44 - 47
25_{II}	15.8 ± 1.3	47 - 50
$25_{II} + 1_I$ ($26_{II} \times 25_{II}$)	13.9 ± 1.5	44 - 46
26_{II}	15.6 ± 1.5	39 - 41

At least one author, Zhebrak,[23] believed an increased chromosome number as such to be sometimes desirable in breeding work, and he endeavored to obtain wheat strains with a high polyploid chromosome number. This raises the question of whether the addition races produced here show any polyploid features. It is generally assumed that some of the characteristics of a polyploid are caused by an increased cell size, which in turn is a function of nuclear volume.[6] The addition of one or two chromosomes constitutes only an average increment of 1/24th or 1/12th and could hardly be evaluated. However, if the diploid morphology of an organism represented a critical equilibrium, the addition of a small amount of chromatin material might have appreciable effects.

Beasley and Brown[1] describe some of their addition products in *Gossypium* as having polyploid features. The stocky appearance of the 25- and 26-paired tobacco plants also suggest a polyploid effect.

In a former paper[5] homology between the *H*-chromosome of tobacco and the *glutinosa* chromosome carrying the necrotic factor was established. A comparison of the haplo-*H*, the normal and the 25- and 26-paired plants—which may be tetrasomic for some of the *H*-factors—shows a gradation from looseness to compactness. If the added chromosome carried incompletely dominant factors for compactness, as the *H*-chromosome of tobacco obviously does, the addition product would be tetrasomic for these factors and hence more compact than the disomic and still more so than the monosomic. Again, the 26-paired plant has short and broad leaves, like a polyploid, in addition to being very stocky, but these are also the proportions of a *glutinosa* leaf. Therefore it cannot be decided, whether the "polyploid" appearance of these types is due to an increase in chromosome number or is a genic dosage effect. A solution of this question could be attempted by adding homologues of a *Tabacum* chromosome which in a monosomic condition causes such "polyploid" features as short broad leaves or an ample corolla. If the effect of the added chromosome were mainly genic, these addition products would deviate in an opposite direction from normal, i.e. would be less polyploid in appearance.

In *Datura*, Sinnott, Houghtaling and Blakeslee[19] find little difference between the average values for the twelve trisomics and the diploid value with reference to most quantitative anatomical characteristics. However, the mean values of the trisomics for the cells of the fundamental tissues measured—subepidermis, cortex and pith of the flower stalk—were on the average significantly larger in the trisomics than in the diploid. Thus a slight increase in chromatin might sometimes have a visible effect.

A survey of chromosome numbers in many families and genera suggests an increase in number from the basic genome or a multiple of it. Some authors[12,18] believe that such numbers could have arisen through fragmentation. Navashin,[14] however, points out that this hypothesis encounters a fundamental difficulty. The newly formed fragments would not function in somatic and reduction divisions without a kinetic body and fragmentation must necessarily leave one fragment lacking this. There is no reliable evidence for *de novo* formation of the centromere. On the other hand, Upcott[20] and Darlington[2] found that misdivision of the centromere of a chromosome with median attachment may result in two telocentric chromosomes. The instability of such chromosomes makes it doubtful, however, whether they can play any role in evolution.

Increase in chromosome number could also be brought about by the addition process described on the foregoing pages. For instance, several aneuploid forms of *Erophila* can be found in the same region. Winge[22] produced true breeding aneuploids in this genus also artifically from hybrids between parents with different chromosome numbers. He showed that the increase in chromosome pairs is brought about by a frequent splitting of univalents in the re-

duction divisions. It should be noted that the Crucifer *Erophila* is preponderantly self-fertilizing. Dehiscence of the pollen occurs in this genus before the petals open. Interfertile forms, growing closely together, will thus be preserved separately. Some hybridization between forms, however, is evidenced by the occurrence of a few plants with univalents. These rare crosses make the working of the hypothesized mechanism possible.

This mechanism would hardly explain the origin of aneuploids in cross-fertilizing plants. Only continual selfings could preserve the aneuploid form, as it would rarely be recovered from the progeny of a cross with either of the parents. For instance a cross between a tobacco plant with 25 and one having 24 pairs of chromosomes would result in a fertile hybrid with 24 pairs plus one univalent, and from such a plant 25-paired offspring would occur only very rarely.

Heilborn[7] pointed out that in some species of *Carex* the chromosome number may have become stabilized just above the true polyploid numbers. *Carex* is a genus with imperfect flowers and therefore cross-fertilizing; it is difficult to believe in the stability of aneuploids with extra chromosomal material in this genus. Wahl[21] in a recent survey of the genus does not support Heilborn's hypothesis for other reasons and favors an explanation of the aneuploid numbers on the basis of a decrease rather than of a building up process.

A series of controlled crosses, backcrosses and selfings are necessary to obtain the addition products, and only isolation can prevent their reverting to the parental type. This applies to the addition of alien chromosomes, which do not conjugate with the others in the same cell. Multivalent formation would make an addition product unstable where there is an affinity between the added and the residual chromosomes. Tetrasomics are unstable. Navashin[14] postulates the possibility of a replacement of the material composing the added chromosome through translocation from one or more non-homologous chromosomes, which would connect genetically necessary material with the added kinetic bodies and differentiate the new chromosomes. Such a process would at least in polyploid species have to occur under isolation from the parental type, as otherwise the added chromosome would be lost before the new type could be stabilized.

In view of these considerations it may be said that chromosome addition may sometimes play a role in taxonomic groups where self-fertilization is an occasionally broken rule. The process could hardly be of general evolutionary significance.

In the eyes of the breeder a basic desideratum for any new strain or variety is genetic stability. This requirement is fulfilled by the addition or substitution races, at least in the specific cases described in this paper. Stability is of greater importance in addition products than in substitution races. Instability of a substituted pair would not have any grave consequences as unbalanced gametes and zygotes would result from the loss of one of the substituted chromosomes. These would not be able to compete. Loss of an added chromosome however, would result in reversion to the less desirable parental type. In the commercial production of addition races the pairing behavior should therefore be studied. A careful selection of seed parents may sometimes be necessary in the perpetuation of the strain. If it were found that in some strains the chromosomes fail frequently to conjugate, the use of such a type would probably be impractical.

Florell[3] and O'Mara[17] observed meiotic irregularities in their wheats with added single pairs of rye chromosomes. This, however, might be an isolated phenomenon restricted to added rye chromosomes, as is suggested by the observations of Lamm[11] on non-conjuction in inbred rye and the frequent occurrence of non-conjuctive pairs in *Triticale* reported by Muentzing.[12]

The effects of changes of chromosomal constitution upon plant habit and morphology are also of concern to the

breeder. Substitution introduces a new linkage group, which can be broken only with difficulty if at all, and thus undesirable changes from the original type may result. Chromosome addition will have less pronounced effects because of a balanced residue.

In the commercial production of new strains with substituted or added chromosomes it may be advantageous to start the breeding program with the interspecific hybrid, rather than to attempt to transfer the foreign chromosome from one variety to another. This latter method would cause a high degree of heterozygosity, which could be lost only in many subsequent backcrosses. On the other hand univalent foreign chromosomes would be rapidly lost in a few backcrosses.

Summary

The addition of entire chromosomes from one species to the unaltered complement of another makes possible the transfer of desirable dominant factors where chromosome pairing and crossing-over fail.

Chromosomes from *N. glutinosa* were added to tobacco by the utilization of artificial polyploidy and a series of backcrosses and selfings.

One of the characters of *N. glutinosa* incorporated in such a manner in tobacco was resistance to the mosaic disease.

The addition races proved to be meiotically rather stable and to breed fairly true.

The possible significance of single chromosome addition in evolution is discussed.

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OCCURRENCE OF RED-EYE IN SWINE

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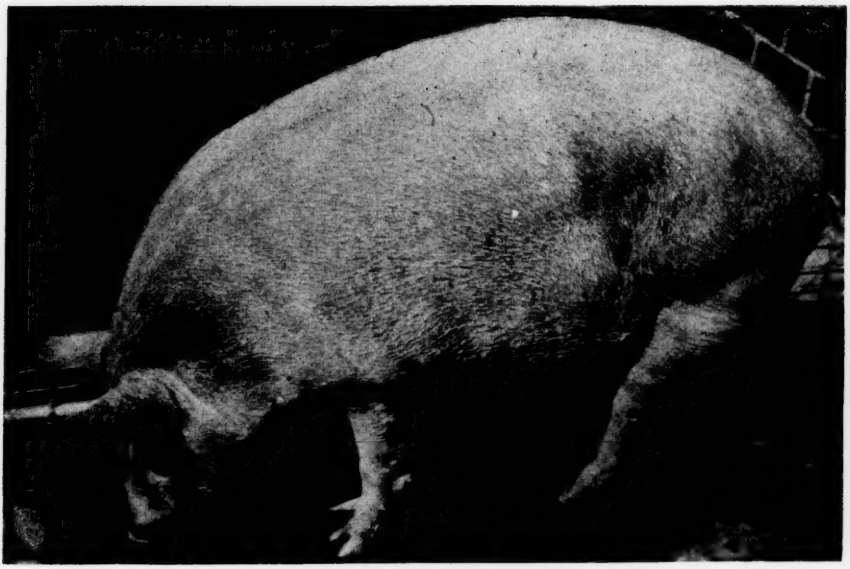


RED-EYED HAMPSHIRE
Figure 6

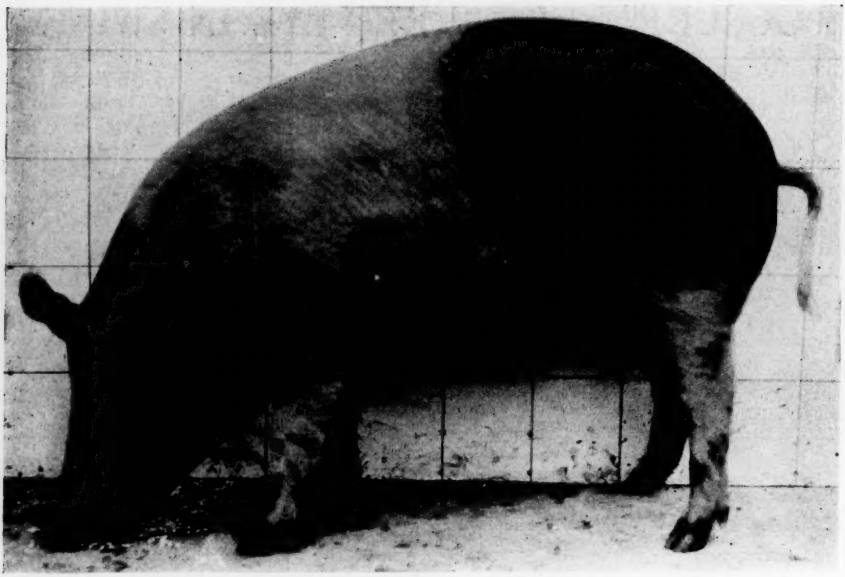
The normal Hampshire (Figure 7) is black and white. This red-eyed individual has the black areas reduced to a light sepia, barely visible in this photograph. In reduction in eye and coat color this variant shows a remarkable parallelism to recessive red-eye in the rat.

McPHEE and Zeller[1] reported the occurrence in Poland China swine of dilute black similar in appearance to the light sepia found in guinea pigs. They designated this new color as sepia. So far as known intensity of eye-pigmentation was not affected.

During a recent study of color markings in Hampshire swine, two red-eyed individuals were found in a litter of nine from registered animals. The phenotypic similarity of these to the red-eyed rat was apparent. The intensity of the red in the eye was about the same as in the rat and the black of the Hampshire pattern was diluted to a light sepia (Figures 6 and 7). One of the two red-eyed pigs, a male, died before sexual maturity, but the other produced a litter from a mating to a half-brother. Also the mother of the red-eyed pigs was mated to one of her sons, since the sire of the red-eyed pigs was not available. The red-eye condition was not recovered in the offspring of either of these matings. Further matings among the progeny are being made.

If this condition is hereditary, as it probably is, it may be a mutation analogous to the red-eye in the rat, reducing the intensity of pigmentation in the eye

*McPHEE, H. C., and J. H. ZELLER, *Jour. Hered.* 16:347-350. 1925.



NORMAL HAMPSHIRE

Figure 7

Dark eye and black spots or a wide white belt characterize this variety of swine.

and coat. The purpose of calling attention to this unusual characteristic before more information is obtained from our breeding results is that others may have observed this trait and will report its recurrence.

✦

Devil's Cul-De-Sac

WHATEVER world organization finally achieves ratification by the Big Five and their fifty little neighbors, will be only the foundation for the painfully built framework of world understanding and cooperation which could assure global peace in our or our children's time. Beyond the fine words and the high hopes, transcending the dangers even of imperialism and world economics, looms a problem so portentous and so perplexing we prefer to ignore it. That is the question of world population.

Perhaps it seems superfluous to harp on this again—it has been the subject of more than one note in this JOURNAL. But it remains perhaps the biggest problem of our time, and it is certainly the most urgent. In spite of the scared "pooh-pooh's" of the wishful thinkers, it remains, as the portentous backdrop of our future. If it is not somehow solved, then all of the agreements and all of the fine words fail.

As a documentation of this point of view, it is interesting to glance over some of the recent volumes of the *Population Index*. This publication could not by any excess of optimism be called easy or integrated reading. Mostly it is abstracts of the current literature of population statistics and research. As a sugar coating to this somewhat formidable drug, six or eight introductory pages are devoted to "Current Items," and these are frequently loaded with economic and sociological block-busters, which, alas, explode in an almost com-

plete vacuum of popular—and even specialist—indifference. For instance, way back in 1940, the Nazi mass-murder program was blue-printed, but nobody paid any attention. It took Buchenwald to make us believe the obvious. During the past couple of years, the *Index* has repeatedly drawn attention to the really explosive population areas of the world, where over half the human race lives, southern and eastern Asia. Three years ago "Current Items" considered the amazing growth of the population in India in the decade 1930-1940. "However, in spite of the world depressions, growth was more rapid than ever before, amounting to 15.2 per cent in the British Provinces and 14.3 in the native states and agencies." In terms of total increase, this came to nearly 51 million people, more than the total population of the British Isles.

In the intervening months the *Index* has considered the population of Japan, China, and Formosa. Each of the surveys has emphasized the fact that in the already tragically over-peopled areas the steady growth of population experienced during recent decades can only end in catastrophe. Relatively small areas like Formosa could serve as regions in which controls of one kind might be tested out. "The problems of the economic and demographic future of Formosa will be minor and dependent aspects of the greatest of all Asiatic problems, the future development of the economy and the population of mainland China."

In the April 1945 issue of the *Index*, the population of Indo-China is discussed. Here is another relatively small-scale "experiment" which demonstrates some of the apparently insuperable difficulties facing the human species as it attempts to deal with the arithmetic of calories produced versus the geometry of mouths to ingest them. The present population of 23 million occupies an area of 740 thousand square kilometers, or a region slightly larger than the state of Texas. As shown in the accompanying dot map, the population is very unevenly distributed, with empty regions and cruel overcrowding almost side-by-side:

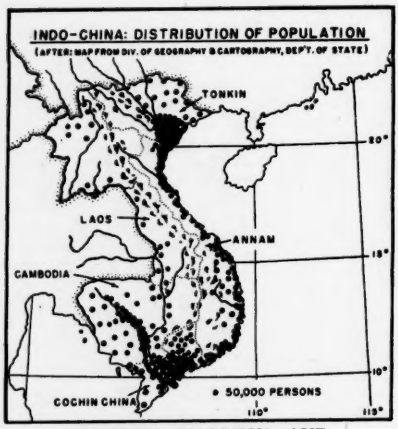
French Indo-China's average density of 31 inhabitants per square kilometer in 1936 might suggest a relatively empty land in the teeming regions of Southern and Eastern Asia that could serve as a partial demographic safety valve for an expanding India or China. Nothing could be further from the truth. Average density figures in Monsoon Asia are meaningless unless interpreted on the basis of the relative prevalence of mountain and delta land. In French Indo-China, as in the Netherlands East Indies, the most striking demographic characteristic is the contiguity of areas of extraordinary density and areas of relative emptiness. The major area of population concentration is the delta of the Red River in Tonkin; here twelve provinces support more than 200 persons per square kilometer; four support over 500. A series of provinces with intermediate density lies along the coast of Annam, where the deltas of the small rivers permit local concentrations of rice farmers. The second major concentration of population is the delta of the Mekong River in Cochin China. There is another secondary concentration along the rivers of Cambodia between the Great Lake and the Cochin China frontier. The mountain provinces are practically empty. No province in Laos has over 8 inhabitants per square kilometer, and twenty-four predominantly mountain provinces in the other four countries have densities of less than 25.

It would appear that the density of population in French Indo-China is a function of delta land and rice culture. If so, the relationship between population, rice area, and rice production should furnish a crude measure of the differential pressure or absence of pressure of people on the land in the various regions. . . . The population figures used in this comparative analysis were those accepted by the Inspection Generale de l'Agriculture. They conform closely to the results of the 1931 "censuses," although some adjustments were made on the basis of field studies and other data.

There are few, if any, large areas in the world in which the pressure of population on the land is greater than in the delta of the Red River, in which are located all the rice provinces of Tonkin. Almost seven million people live in the sixteen provinces which lie wholly or in part in this delta. They secure their major subsistence from only *twelve thousand square kilometers of rice land.* Density of settlement per square kilometer of rice land is 586 for the delta as a whole, 734 for the middle delta, and 743 for the lower delta.

* * * *

There is thoroughly conclusive evidence that the populations of Cochin China and Cambodia have been increasing at from 1.0 to 1.5 per cent per year. [Some alleviation of the overcrowded conditions in the river valleys



TEEMING VALLEYS AND EMPTY HIGHLANDS
Figure 8

might be achieved by a redistribution of population, but] increasing demographic inbalance, continued dependence on rice culture, a deepening poverty in the densely settled areas of the east and north, and appallingly high mortality have been interrelated aspects of the partial absorption of French Indo-China into the political and economic system of the West. Both material standards and cultural values have changed. Tenancy, indebtedness, and the fragmentation of holdings have increased in Tonkin and Annam, but the levels of living appear to have risen for large groups in the Mekong delta. At least a minimum knowledge of and desire for European goods and services have permeated all areas. The prestige of the old Annamite and Cambodian dignitaries is reported to be decreasing. Cities remain few and industrial employment limited, but increasing proportions of Annamite and Cambodian youth have experienced urban life and wage employment and have returned to their homes to constitute centers for the diffusion of knowledge of the new ways of life. Some 431 thousand native youth, 57 thousand of whom were girls, were attending school in 1937.

* * * *

The only rational economic and demographic policy for the French Indo-China of the postwar period would appear to be industrialization. The natural resources for both heavy and light industry are present, but there are deficiencies in capital, technical and managerial personnel, and experienced labor. More effective agricultural education, the introduction of new varieties of rice, and increased fertilization could increase unit yields of rice far beyond the present level, which is the lowest of any of the major rice-producing areas of Asia. Adequately planned and financed colonization projects could result in an expansion of the cultivated area. Such agricultural developments oriented toward more diversified production for regional consumption within an expanding industrial economy might offer possibilities for increasing levels of living. If oriented toward the increased production of the great export crops of rice and rubber, they might contribute primarily toward the development of a more efficient but even more unstable dual economy. The history of other colonial areas indicates that the achievement of these agricultural improvements alone, however oriented, would be accompanied by a rapid decline of the death rate and a further rise in the rate of natural increase. A comprehensive agrarian program might be only a race between demographic and economic expansion.

The Red River delta of Tonkin presents in miniature the almost insuperable economic difficulties involved in the achievement of adequate nutrition and a reasonable expectation of life for a people if the entire demographic transition from high mortality and high fertility to low mortality and low fertility must occur in an area with an already redundant population. The creation of an expanding agricultural-industrial economy that eventually would provide a milieu favorable to declining fertility and the achievement of population stability would be much simpler in the more prosperous and less densely settled Mekong delta.

In French Indo-China the density of settlement in the deltas is a function of the antiquity of a stable rice culture. If this is generally true, it is only a matter of time until the Mekong delta of French Indo-China itself, the Irrawaddy delta of Burma, and the Menam delta of Thailand reach the density of population now characteristic of the delta of the Red River. These three deltas now constitute the world's most important areas of commercial rice production for the export trade. If rates of population increase remain unchecked, these regions must ultimately become rice deficit areas. The increasing imbalance between people and resources created by the dual economies of Southeastern Asia must eventually undermine those economies.

There, in miniature, seems to be the major paradox of our time. To shift culture patterns would take at least several generations. But even as we attempt such a shift in the face of continued high fertility, the explosion in growth of numbers is so great that the second phase is never reached. To cut the Gordian knot of this surpassing paradox will involve social inventiveness of a high order. Hush-hush and vague good intentions can never be enough. But it seems to be the only solution likely to be applied at the present time.—R. C.

A PEDIGREE OF CURVED FOREFINGERS*

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MANY congenital anomalies of the hands have been reported, but little systematic study of normal hand characters appears to have been made. The purpose of this paper is to present the results of an investigation of curved fingers, a hand variation which has been diagnosed by radiologists as within the range of normal structure. Simply inherited non-pathological human traits are important not only as markers in linkage studies, but are of considerable value as a means of educating the public regarding heredity.

The trait we are reporting is illustrated in Figures 9 to 12. Figure 10 shows the curvature of the forefinger which is characteristic of many persons in the families studied. In this figure digits other than the forefinger are also curved, but in Figure 9 only the forefingers show a distinct curvature. Since there seems to be a predominance of curved index fingers among the curved digits studied, the authors concentrated largely on the study of this particular digit. However, some general observations were made on the curvature of other fingers and these are also discussed.

The curved forefingers of the pedigree in Figure 11 are characterized by a variable deviation to the ulnar side of the two distal phalanges of one or both index fingers (Figures 9 and 10).

Clinodactyly is a technical term which has been used to describe a permanent lateral deviation of the phalanges. Although technically it would be correct to speak of curved forefingers, shown in Figure 10, as clinodactyly, nevertheless, insofar as usage is concerned it would appear that clinodactyly is a term which has been largely applied to those lateral deviations of the phalanges which are so great as to be recognized as pathological variations of the fingers. For example Iltis[14] illustrates clinodactyly in the brachydactylous hands of a mother and daughter. In these cases the inclination of the fingers is quite obvious. However, only the most critical observer would note the curvature of the forefingers illustrated in Figure 9. In fact some members of this family were not aware of the fact that there was any curvature of their fingers until it was brought to their attention by this investigation. Curvature of the forefingers within the range found in this study did not in any way impair the function of the affected digits.

As pointed out above there seems to be little literature on a systematic study of curved forefingers. Whitney[26] mentions that such a trait does seem to run in families, but does not indicate the mode of inheritance. It would seem logical to assume that the difference between a case of curved fingers such as discussed in this paper and typical clinodactyly is only one of degree. Clinodactyly has been studied by Barbosa Sueiro and Fontes,[2] Dubreuil-Chamberdel,[4] Mauclaire,[15] Nowak,[18] Tomesku,[24] and Zurukzoglu.[27]

Many papers have been published on camptodactyly, a hereditary distortion of the finger resulting in a fixed flexion or, less common, in a fixed extension. It has been suggested that the term streblomicrodactyly be reserved for bent little finger as contrasted with camptodactyly which merely means bent finger and is applicable to any digit.

Although in some pedigrees camptodactyly and streblomicrodactyly skip

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It is also a pleasure to acknowledge the assistance of Dr. Jeannette Dean-Throckmorton, Medical Librarian, Iowa State Medical Library.

CURVED INDEX FINGERS

Figure 9

The forefingers of III-21 (Figure 11) are decidedly curved away from the thumbs. All the other digits are straight. X-ray examination revealed nothing that would be interpreted as a skeletal defect.

generations, there seems to be a considerable amount of evidence that they are dominant characters. In fact, a number of different studies indicate simple dominance.*

Description of Pedigree

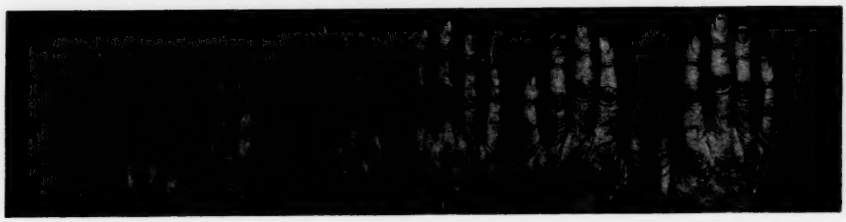
This pedigree of curved forefingers has been traced through four generations as will be observed in Figure 11. There is no information available regarding the parents of I-1-2-3-4, so it is not known when the trait first became manifest. I-1 showed the character in both hands, but no information could be obtained about I-2 for she had been dead for several years. However, it is suspected that she exhibited the trait, for her six children possess curved forefingers. I-3 exhibited curvature of the index fingers to only a slight degree while there was an absence of curvature in I-4. However, approximately half of their children show marked curvature of the forefingers.

The curvature of the forefinger is variable, but not to a striking degree. The variation shown in Figures 9 and 10 is fairly typical. While most individuals show the same amount of curvature in both hands, yet, as indicated in Figure 11, some exhibit more curvature in the right than in the left forefinger. Others show more pronounced curvature of the left forefinger than of the right. There are some definite asymmetries in which there is a unilateral expression of the trait. Cases of this are III-1, III-22, III-23, but it will be observed that in every instance of unilateral expression it is always the right hand which shows the character.

Figures 9 and 10 are the hands of one family and a comparative study reveals great likenesses. It is interesting to note that one daughter (III-20) has hands very similar to those of her mother (II-12); both have long fingers and the hands are relatively thinner than those of the sister (III-21) and the father (II-13). It will be observed that not only do the index fingers of III-20 and II-12 show much similarity, but all the other digits are nearly identical in form. The little and middle fingers are slightly curved, and the middle finger (third digits) are also slightly rotated. The middle finger on the right hand of III-20 was crushed in the jamb of a car door which accounts for the distal phalanx being displaced at a rather sharp angle to the ulnar side of the hand.

The hands of the daughter (III-21) are more like her father's (II-13) than

*Papers pertinent to studies on camptodactyly have been published by Dreyfus,[3] Gassul,[5] Allan,[1] Heerup,[9] Gassul,[6] Hefner,[10] Hefner,[11] Herbert,[12] Maurer,[16] Glass and Magee,[7] Moore,[17] Ritterskamp,[19] Schmidt,[20] Schultze,[21] Stoddard,[23] and Wahmann.[25]



HANDS OF PARENTS AND OFFSPRING

Figure 10

Here are shown, from right to left, the hands of the father (II-13), the mother (II-12) and of the daughter (III-20). Here both the index finger and the little finger are curved inward. Though inherited from both parents the character is no more extremely expressed in the daughter. The study of such normal and nondisfiguring family traits is a fascinating subject. Casual observation will reveal many such characteristics among one's day-by-day contacts with people.

her mother's (II-12). Both father and daughter have relatively short fingers and broad hands.

The nature of the curvature of the forefingers of III-21 and II-13 is almost identical. The little finger on the left hand of II-13 was broken which increased the displacement to the radial side of the hand. Otherwise the similarity of the father's hands with one of the daughter's corresponds about as closely as that of the mother's hands with the other daughter's.

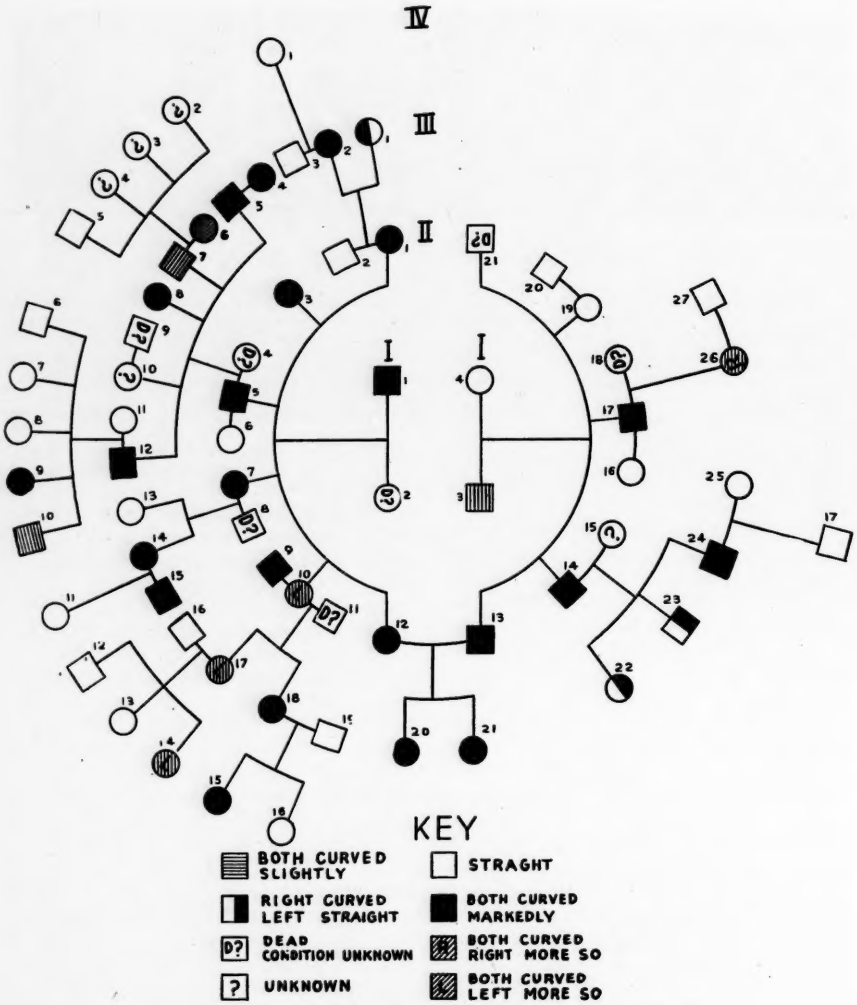
In an effort to simplify the pedigree chart (Figure 11) only the inheritance of curved forefingers was included. However, some descriptions of other digits and their comparison with the forefingers is of interest. Brief descriptions and comparisons follow:

II-5, Little fingers and forefingers curved.
II-7, Little fingers and forefingers curved about the same. Third and fourth digits curved toward each other like a pair of parentheses.
II-10, Little fingers curved about the same as forefingers. Third and fourth digits straight.
II-13, Little fingers more curved than the index fingers.
III-6, Little fingers and forefingers slightly curved. Third and fourth digits straight.
III-11, All fingers straight except little fingers slightly curved.
III-13, Little fingers slightly curved, but forefingers normal.
III-14, Little fingers slightly curved and forefingers more so.
III-15, Little fingers and forefingers curved. Third and fourth digits curve toward each other.
III-18, Little fingers and forefingers curved.
III-19, Left little finger curved.
IV-6, All fingers straight.
IV-7, All fingers straight.
IV-8, All fingers straight.
IV-9, Little fingers slightly curved, but forefingers markedly curved.
IV-10, Little fingers and forefingers curved very slightly.

These data indicate that if any fingers of an individual show curvature, the forefingers are likely to be involved; however, there are some persons in whom the little finger is curved but the index finger is straight. Obviously, it is the forefinger and the little finger which are most frequently curved. In some cases the third and fourth fingers are also curved in addition to a curvature of the index and little finger, but this is not always true. Furthermore, it is found that even if all fingers show curvature, it is most pronounced in the second and fifth digits.

Cause of Curved Fingers

The X-ray photograph (Figure 12) shows very well the skeletal structure of the hands of III-21. The radiologist who read the X-ray film diagnosed the hands as negative; in other words, they were considered perfectly normal from an anatomical point of view. If one side of a phalanx were higher than the other,



INHERITANCE OF CURVED FOREFINGERS

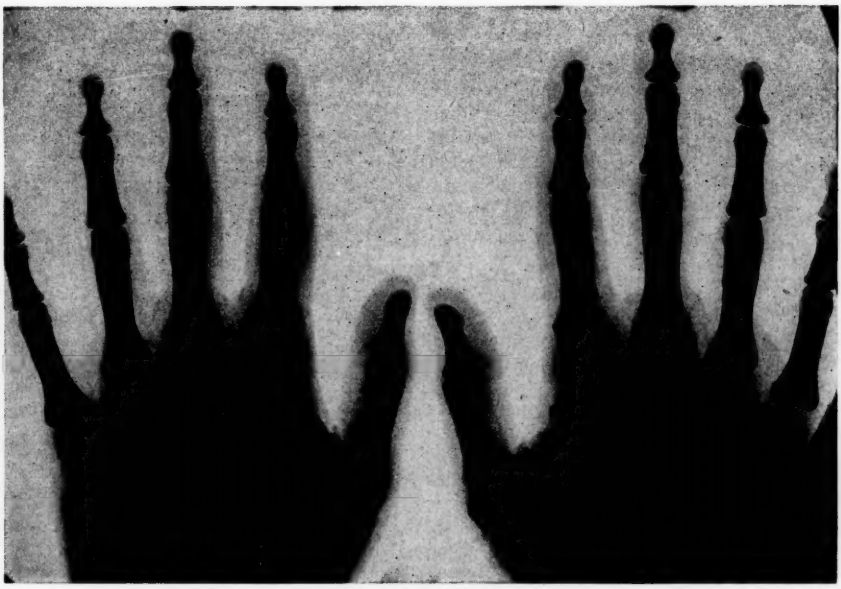
Figure 11

Four generations of inheritance of a slight and non-pathological curvature of the forefingers. Since the character is transmitted in varying degrees from parent to offspring without any skipped generation, a simple dominant inheritance is suggested.

it might produce curvature of the finger; however, this was not observed in the case of III-21. Therefore, it is suspected that the curvature of the young woman's forefingers is probably due largely to the soft parts of the hands.

Discussion

Curved forefingers is not a pathological trait. Few persons would notice curved index fingers unless attention were directed to them, and no functional disorder attends the condition.



NO DEFECT OF BONES OR JOINTS

Figure 12

X-ray photograph of the hands of III-21. Both the index fingers are slightly curved to the ulnar side in the region of the last two phalanges. The bony structure is considered entirely normal by radiological examination and apparently the curvature is due to the structure of the soft parts of the fingers.

The frequency with which persons with curved forefingers married other individuals with curved forefingers (Figure 11) makes it reasonable to assume that there is a fairly high incidence of curved index fingers in the general population. Personal observations of the authors confirm this assumption.

The pedigree chart (Figure 11) shows a fairly high incidence of curved forefingers, and the distribution and ratio of curved forefingers to straight forefingers is in harmony with a single gene interpretation, in which the curved digit is dominant to the absence of curvature. As pointed out earlier, camptodactyly, a different kind of curvature of the fingers, is often dominant.

Iltis[14] and others have found brachydactyly associated with curved fingers. However, there was no hint of brachydactyly in any individual of this study. Therefore, the two conditions are not necessarily concomitant.

In cases where the curved forefinger is unilateral in expression, it is always the right forefinger which is affected. Also there is a tendency for curvature of the right to be greater than that of the left. Likewise Stiles[22] found in the asymmetrical expression of pitted ear that the pit was found more frequently in the right than the left ear. Stoddard[23] pointed out in his study of four generations of streblomicrodactyly that if the trait appeared only in one hand it was always the little finger of the right hand affected. Gutmann[8] presents a pedigree of hammertoe in which seven persons are affected. The deformity developed only on the second toe of the right foot. The reasons for the unilateral expression of a bilateral trait are obscure. Stiles[22] considered the unilateral

development of pitted ear as probably due to internal environmental factors acting during the early stages of embryogeny.

However, some experimental studies have demonstrated that the right-left incidence of a character may be influenced by genetic modifiers. Therefore, genetical as well as environmental influences may play a part in producing unilateral traits.

Hoffman[13] describes a case of unilateral mammary hypoplasia in a sixteen year old girl. This girl possesses one very well developed breast while the other is rudimentary. Hoffman states that the unequal response of the breasts to presumably identical hormonal environment emphasizes the importance of local tissue reactivity. He concludes that where the mammary hypoplasia is unilateral, the fault apparently lies in the reactivity of the affected breast. Such a marked disparity might be due to a mammary chimera, resulting from somatic mutation or chromosomal aberration.

Summary

1. This study traces curved forefingers through four generations.

2. The character is not considered pathological.

3. A study of the pedigree makes it appear probable that curvature of the forefingers is dependent upon a dominant gene.

4. Curved forefinger is unilateral in expression in three cases. When the trait is unilaterally expressed the right hand is always the one affected.

5. Curved forefinger is usually associated with some curvature of the little finger. In some cases the third and fourth fingers also show curvature.

6. Insofar as this pedigree is concerned, curved forefinger is not associated with camptodactyly or brachydactyly as some others have found.

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A WHITE BLACKBERRY

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IN the spring of 1941 the author discovered a large pure colony of white-fruited blackberries some distance north of Gainesville, Fla. They were growing wild in open ground not far from a large patch of the common sand blackberry, *Rubus cuneifolius* Pursh. Since the new plants were similar to this species in size, vigor and general appearance the name assigned by the author to his discovery was *R. cuneifolius* forma *albifructus,* which was afterwards published in *Science.*

A few days later another large pure colony of the new form was located in the eastern part of Alachua County. In the herbarium of the Experiment Station a mounted plant of this form was also found, collected by Mr. E. West near Gainesville in 1934.

White-fruited balckberries have been reported from widely different regions and may occur in almost any species. In 1890, Dr. L. H. Bailey described *Rubus villosus* var. *albinus.* Prior to 1859, at Albion, Ill., Mr. J. B. Orange raised from seed the commercial form known as Crystal White, which is a form of *Rubus louisiana* Berger. Luther Burbank took Orange's plant and crossed it with the Lawton, obtaining a whitish berry known to the trade as the Iceberg. In 1940, W. N. Scarff's Sons, of New Carlisle, Ohio, were still listing this plant as a novelty.

Both the Iceberg and the Crystal White are rather low-grade forms, the fruit being somewhat mushy, sweet but insipid, and not keeping well. They are better for local consumption than for shipping any great distance. In case the berries are too sweet a little lemon juice may be added or a mixture of white and black fruits used. In canning, a little vinegar or citric acid would serve the same purpose.

The sand blackberry is native to this section of Florida and rarely fails to yield an abundant crop of delicious

WHITE BLACKBERRIES

Figure 13

White variants of the common sand blackberry have been found in at least three points near Gainesville, Florida. The flavor tends to be somewhat less sprightly than that of the normal black form, but this deficiency can perhaps be corrected by breeding. Since the white blackberry stains neither the fingers nor the teeth, it would probably be preferred by some people.

fruits without any cultivation whatsoever. Its white-fruited form appears to be fully as vigorous and reliable as a fruit-bearer; and under cultural conditions, with care in selection, it might be improved in size and flavor. Some women object to berries that blacken their fingers and teeth. Perhaps the white blackberry may fill a long-felt want in this respect.

In the summer of 1941 seeds from both colonies of white-fruited plants were germinated in a greenhouse and the young plants removed to open ground the following spring. It took two years to obtain fruit. In May, 1943, 104 bushes were in bearing; but every berry on every bush was black! A row of bushes transplanted from one of the original wild colonies bore only white fruits.

In March, 1944, many experiments were tried with the transplanted white-fruited plants. The results showed conclusively that the fruits do not develop without pollination, and that the form is entirely self-incompatible, requiring cross-pollination from black-fruited plants to produce fruits at all. Black being dominant, the seeds of these fruits give rise to black-fruited plants, as stated above.

It is interesting to speculate on the probable origin of this white-fruited form. In some recent studies of maize, chromosomes have been found broken at the tip with four or five genes gone, among which there might have been a color gene. Something of this kind may happen once in a while in the blackberries.

This subject has been discussed at some length with Dr. A. B. Stout, of the New York Botanical Garden. In July, 1944, he wrote me as follows:

"Your white-fruited blackberry would, I presume, be called a mutation and since white is recessive your one plant from which the clone was derived must have been homozygous (*ww*). Your F_1 plants would then be heterozygous (*wB*). If you backcross these with homozygous-blacks (*wB* × *BB*) you can never expect to obtain any white-fruited offspring. Your only hope to get white-fruited segregates among seedlings is to crossbreed *wB* plants."

I am indebted to Dr. W. B. Tisdale, Dr. F. H. Hull and Mr. R. J. Wilmot for assistance.

✦

Standardizing the Phenotype

Personality structure in the United States varies according to locale, region, and class. These variations reflect the fact that our culture is not homogeneous. We can, however, safely posit a few tendencies identifiable as typically American. As between regional and class differences, those of class seem the more decisive in personality formation. If we want to find the power house for racial prejudice, we shall have to spot those sectors of the population that have the most to gain by the expression of hostility. In order to do this, we should have to look at class structure in America, as well as at the regional variation in culture. A planned attack on prejudice will have to take these differences into account by separate, but coordinated plans for each particular region and every class within it.

* * * *

In our American culture, the limits to behavior are narrowly imposed by our strict child-training methods. True enough, individualism is one of our ideals. But can we afford to risk our social structure on such an ideal? For by the very way in which we train our children, we make certain that they can never really carry individualism very far, or take full advantage of being themselves. This is the crux of our particular system of social control. We must, then, be wary of going too far in our relaxation on child training until we see where we want to go in terms of the social structure we believe we should have. Whether our aim is to reduce race prejudice or to produce less neurotic adults, the changes should be in terms of "better child care," rather than in terms of the more specific objectives.—Scudder Mekeel, in *Mental Hygiene*, April 1945, p. 182.

INHERITANCE OF STEM CHARACTERS

In Certain Sorghum Varieties and Their Hybrids

A. M. SCHLEHUBER*

THE inheritance in sorghum of the factor pairs dry *vs.* juicy and sweet *vs.* non-sweet has been investigated.[1,2,3] The earlier studies[1,3] were not based on the analyses of the extracted juice, but in 1935 Ayyangar[2] reported extractions of 17 to 20 per cent of total weight in "pithy" stalks, and 33 to 48 per cent in juicy ones. While the actual "degrees Brix" (total solids) and sucrose values were not given, Ayyangar reported a difference in Brix between sweet and "insipid" of about 3.5 per cent with a similar difference in sucrose content.

The association of the characters dry with white mid-rib of the leaf and juicy with a dull grey or cloudy mid-rib has been noted and has been used as evidence that the characters dry and non-sweet are dominant over juicy and sweet.

The data in this report are based on the analyses for Brix and per cent sucrose of the extracted juice, and the length, diameter, and weight by internodes of parents and F_1 plants that was found in studies to determine the possibility of utilizing heterosis in developing strains combining high percentage of sucrose and high yield.

Materials and Methods

The sorghum crosses, Collier M. N.† 45 × *S. vulgare* M. N. 352 (F. P. I.‡ 92262) and reciprocal, Straightneck M. N. 29 × Collier M. N. 45, and Honey Dew Drip M. N. 385 × Collier M. N. 258 were made in 1943. In 1944, five seeds per parent and from one to three crossed seed per pot were planted in the greenhouse on April 18, in 2.5 inch paper pots. After complete emergence, all stands were thinned to one plant per pot and on April 29 all plants were transplanted to the field, one foot between plants, in rows 3.25 feet apart. The hybrids were planted between their respective parents.

For the internodal measurements of length, diameter, and weight primary tillers were used; for juice analyses, a composite of several plants consisting largely of secondary tillers. The juice was extracted by one crushing of the stalks through a power-driven three-roller mill, with the same mill-set for all extractions.

Experimental Results

Collier × *Sorghum vulgare* and Reciprocal

Sorghum vulgare M. N. 352 is a "dry", non-sweet grain sorghum which grows rapidly, producing few or no tillers, and matures early. If harvested when the seed is mature very little juice (10-15 per cent) can be extracted from the stalks. It yielded about 26 per cent juice harvested when the seed was in the soft dough stage (see Table I). Collier is a juicy, sweet-stalked sorgo that produced about 54 per cent juice harvested in the ripe stage. The F_1 hybrids yielded 38.3 and 39.5 per cent of juice, respectively, approximately equal to the mean extraction of the two parents. In this cross, then, dryness of stalk is not dominant over juiciness.

Length, diameter, and weight by internodes of the three plants represented in Figure 14 are presented in Table II. For a given volume of stalk the principal factor in determining the weight is the amount of juice in the stalk. In Figure 15 the relationship of weight of

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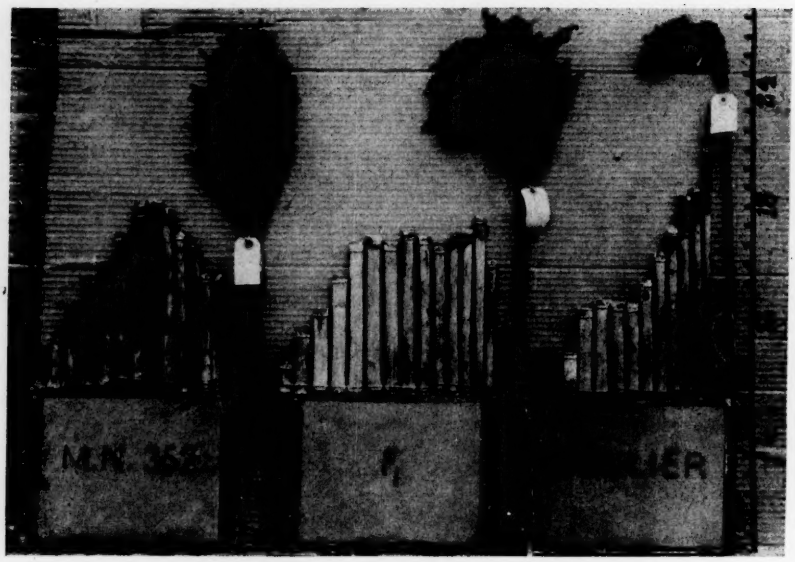
†M. N. refers to accession numbers used at the U. S. Sugar Plant Field Station, Meridian, Mississippi.

‡F. P. I. refers to accession numbers of Foreign Plant Introductions.



F_1 SORGHUM × SORGO AND PARENTS

Figure 14

Successive internodes from root to peduncle (left to right) and panicles from primary tillers of *Sorghum vulgare* (M. N. 352), the F_1, and Collier, sorgo (M. N. 45) grown near Meridian, Miss., in 1944. M. N. 352 is a dry, nonsweet, grain sorghum from which very little juice can be extracted after the seed is ripe, but which yields a fair amount of juice if harvested when the seed is in the soft dough stage. It grows rapidly, producing few or no tillers, and matures early. The F_1 "growth pattern" is different from either parent.

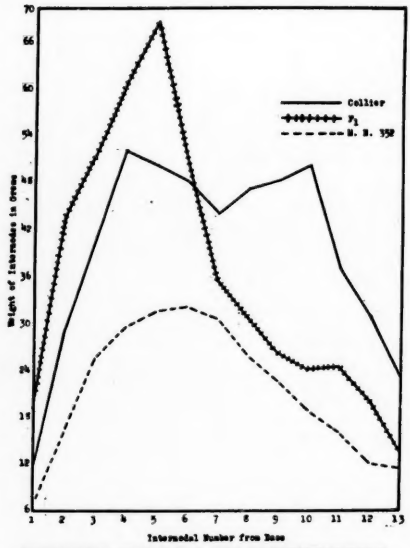
internodes of the F_1 hybrids and the parents is depicted. It can be noted that in the lower internodes the weight of the F_1 exceeds that of either parent and that only in the upper internodes does the F_1 weight approximate that of the dry-stemmed parent.

Straightneck × Collier

This is a cross between two juicy, sweet-stalked varieties of sorgo. Agronomic data and results from juice analyses of the parents and F_1 are presented in Table I. Detailed data by internodes were obtained in this cross just as in Collier × *S. vulgare*; however, here the chief points of interest are in the juice analyses and average stalk weights.

Based on the combined weights of primary and secondary tillers, the average weight per stalk is as follows: Straightneck, 532 grams; Collier, 426 grams; and F_1, 504 grams. The F_1 weight is 5 per cent less than that of Straightback but exceeds Collier by 18 per cent.

Total solids and per cent sucrose, i.e., *quality* of juice, is higher in either parent than in the F_1 (Table I). The comparative Brix values are: Straightneck, 17.44; Collier, 18.36; F_1, 16.84; per cent sucrose: Straightneck, 13.49; Collier, 14.01; and F_1, 12.59. In *quantity* of total solids and of sucrose per stalk, the F_1 is equal to the mean of the two parents in total solids and lacks only one gram of being equal to the mean of the two parents in sucrose. For example, Straightneck produced 48.6 grams of total solids (532 grams × 52.4% × 17.44 Brix); Collier, 38.5 grams; F_1, 43.5 grams. The mean of the two parents is also 43.5 grams. A similar comparison for grams of sucrose per stalk



WEIGHT CURVES BY INTERNODES OF F_1 AND PARENTS

Figure 15

Collier sorgo is a juicy-stalked variety; M. N. 352 is "dry." In total amount of juice, the F_1 is approximately equal to the mean of the two parents. For a given volume of stalk, the chief factor in determining weight is the amount of juice. In the lower internodes the F_1 weights exceed either parent but in the upper internodes the F_1 weight is close to that of the dry parent.

gives the following results: 37.6 grams for Straightneck (532 grams × 52.4% × 13.49% sucrose); 29.4 grams for Collier; and 32.5 grams for the F_1. The mean of the two parents is 33.5. Hence, from the standpoint of amount of total solids and of sucrose per stalk, the F_1 is intermediate between the two parents.

Honey Dew Drip × Collier M. N. 258

This is another cross between two juicy varieties of sorgo. Agronomic data and results from juice analyses of both parents and the F_1 are presented in Table I. This is the only cross studied up to date in which both the stalk weight and the juice quality of the F_1 exceed that of either parent. A comparison between the F_1 and the two parents of certain analyses and characters is presented in Table III. The average weight of primary tillers of the F_1 exceeds Collier by 172 per cent and Honey Dew Drip by 43. In secondary tillers, the F_1 is 133 per cent heavier than Collier and 21 per cent heavier than Honey Dew Drip. By either standard of comparison the F_1 manifests considerable hybrid vigor.

Table I.—Agronomic data and results from juice analyses from F_1 sorghum hybrids and parents grown near Meridian, Miss. in 1924

Parent or Cross	Av. stalk weight (lbs.)	% Ext.	Degrees Brix	% sucrose	% apparent purity	Stage (seed) at harvest	Date Harvested
Collier, M. N. 45	0.87	53.8	16.64	14.05	84.4	Ripe	8-26
Collier x M. N. 352 F_1	0.75	54.3	15.39	10.51	68.3	Hard dough-ripe	8-16
M. N. 352 x Collier F_1	0.76	59.5	15.49	10.70	69.1	Hard dough-ripe	8-16
M. N. 352	0.70	25.7	14.84	9.82	66.2	Soft dough	8-5
Straightneck, M. N. 29	1.05	52.4	17.44	13.49	77.4	Ripe	8-26
Straightneck x Collier F_1	1.05	51.2	16.84	12.59	74.8	Ripe	8-26
Collier, M. N. 45	0.90	49.2	18.36	14.01	76.3	Ripe	8-26
Honey Dew Drip	1.54	55.8	14.57	9.49	65.1	Hard dough-ripe	9-18
M. D. D. x Collier M. N.	1.86	57.7	15.57	9.87	63.4	Ripe	9-18
Collier, M. N. 258	0.80	55.0	14.89	9.27	62.3	Soft to hard dough	8-16

Table III.—A comparison of characters between Collier, M. N. 258, Honey Dew Drip, and F_1 sorgo plants.

Analysis or character	Parents or Hybrid			F_1 percentage of Honey Dew Drip
	Collier M. N. 258	Honey Dew Drip	F_1	
Av. stalk wt. of primary tillers (gms.)	495	945	1,347	142.5
Av. stalk wt. of secondary tillers (lbs.)	0.80	1.54	1.86	120.8
Per cent Extraction	55.0	55.8	57.7	103.4
Degrees Brix	14.89	14.57	15.57	106.9
Per cent Sucrose	9.27	9.49	9.87	104.0
Per cent Purity	62.3	65.1	63.4	97.4
Av. length of internodes (cms.)	14.7	15.2	16.4	107.9
Av. no. of internodes	13.0	19.0	19.5	102.6
Av. wt. of internodes (grams)	38.1	49.7	69.1	139.0

Table II.—Data on Collier, M. N. 352, and F_1 sorgo plants represented in Figure.

Internode No.	Length (cms.)	Diam. (cms.)	Weight (grams)
Collier (M. N. 45) Sel. 2704-2			
1	2.5	1.85	8
2	5.5	2.00	19
3	11.5	2.05	40
4	12.5	2.05	45
5	12.5	2.00	41
6	12.5	1.90	37
7	15.0	1.85	42
8	19.0	1.75	49
9	27.5	1.65	52
10	26.5	1.50	42
11	28.0	1.35	42
12	33.0	1.15	33
Collier x M. N. 352 F_1 - Sel. 2705-4			
1	4.0	2.10	15
2	8.5	2.20	33
3	11.0	2.20	41
4	15.5	2.10	51
5	20.5	2.05	59
6	21.0	2.05	65
7	20.0	1.95	55
8	21.5	1.85	53
9	21.0	1.75	54
10	20.0	1.60	42
11	21.0	1.55	42
12	22.0	1.45	38
13	24.0	1.35	36
14	17.5	1.25	32
M. N. 352 (F. P. I. 22262) - Sel. 2707-1			
1	4.0	1.85	7
2	7.0	1.60	14
3	10.5	1.70	22
4	15.0	1.80	31
5	16.5	1.85	39
6	20.5	1.85	39
7	24.5	1.80	39
8	25.0	1.80	36
9	24.0	1.65	33
10	21.0	1.55	28
11	19.0	1.50	26
12	15.5	1.35	21
13	15.0	1.30	20

Summary

Analytical results from the juice and measurements of stalk characters from three sorghum crosses in the F_1 generation are presented.

In the cross Collier (juicy) × *S. vulgare,* M. N. 352 (dry), juiciness of F_1 was intermediate between the two parents. In the lower internodes the F_1 weights exceed either parent; in the upper internodes the F_1 weights approximate those of *S. vulgare,* the dry parent. The F_1 "growth pattern," expressed in relative length of internodes, was different from either parent.

In Straightneck × Collier, two juicy, sweet-stalked varieties, the juice quality, as expressed by per cent total solids and per cent sucrose of the F_1 was lower than of either parent. However, in amounts of total solids and of sucrose per stalk, the F_1 was approximately equal to the mean of the two parents.

In a juicy-stalked × juicy-stalked cross, Honey Dew Drip × Collier, M. N. 258, the F_1 exceeded either parent in both average stalk weight and quality of juice.

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✦

NEW SYMBOLS FOR PEDIGREE CHARTS

Suggestions for the Improved Symbolic Representation of Data in Pedigree Charts

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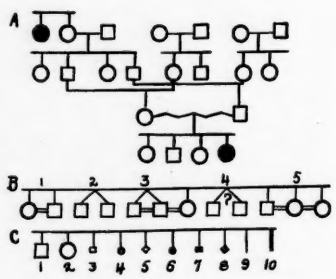
IN the construction of standard pedigree charts such as those published in the Journal of Heredity several alterations might be made which, in my estimation, would improve the chart. I realize that acceptance of these suggestions will not be universal, but believe their adoption would increase accuracy and detail of data recorded.

Miscarriages and Stillbirths

The standard procedure for representation of miscarriages or stillbirths is a small circle in solid black. This is confusing on two counts. First, circles are already used in the pedigrees to represent females; second, the solid black symbol is used to denote persons affected with the trait with which the pedigree deals. From the use of these symbols elsewhere in the pedigree one might be justified in interpreting the



NEW SYMBOLS FOR PEDIGREE RECORDS

Figure 16

This chart shows some of the changes suggested in the accompanying text. *A* shows the zigzag line suggested to call attention to cousin marriages. *B* shows the method of differentiating fraternal and identical multiple births. *C* shows the symbols suggested to symbolize data regarding still-births.

symbol denoting a miscarriage as a miscarriage of the female sex affected with the trait present in other individuals in the family. This is not what is meant. Actually it is possible to establish the sex of the fetus after the twelfth week of gestation and often even to determine whether the miscarriage has been affected with a defect being studied. It is obviously desirable to have a system of representing these facts with respect to the miscarriages. I would suggest that the following symbols be used:

1. A small square to denote a miscarriage or stillbirth of the male sex, and not known to be affected with the trait being studied. (See Figure 16 *C3*.)

2. A small circle for a female miscarriage supposedly unaffected. (See Figure 16 *C4*.)

3. A small diamond for a miscarriage whose sex is not known but which was presumably old enough to have the sex determined. (See Figure 16 *C5*.)

4. These same symbols filled in with black if the miscarriage was affected. This is easily determined in many skeletal defects, such as polydactyly, brachydactyly, anencephaly, spina bifida, club foot or hand, absent digits or in hydrocaphalus, ectopia cordis, exomphalos, hare lip, etc. This might be extended to a very long list of defects recognizable in the fetus.

5. If the miscarriage was lost before sex was identifiable with certainy, it might be represented as in C9. If the miscarriage was before this time, but recognizably defective, it might be represented as in C10. I remember having an eight weeks embryo with obvious anencephaly and complete spina bifida. Since the sex is unknown in these early products of conception, they might be represented by a diamond either clear or in solid black, thus eliminating the symbols C9 and C10.

It is obvious that in dealing with traits that are not recognizable until after birth, miscarriages cannot be designated by other than clear symbols, but sex should be inquired for and represented when known. This is particularly of interest in any defect or trait which in general tends to affect one sex more than the other, or to be limited to one sex in any one family. This information might explain some of the apparent pecularities in sex ratios sometimes found in these families. It might also disclose whether there is a tendency for some of these abnormalities not obviously detrimental to be associated with other conditions which cause the early death of the fetus.

Cousin Marriages

In small pedigrees it is usually obvious when a mating between related persons occurs, but it sometimes becomes extremely confusing to follow the marriage lines when large families are involved, or when the relationship is between second cousins, or those even more distantly related. The words "cousin marriage" may become so reduced in the published pedigree as to be undecipherable. I would suggest that all marriages between related persons be distinguished in the pedigree by saw-toothed lines instead of the traditional straight "marriage line" joining the square and circle. This at once calls attention to the consanguineous mating, and saves the laborious tracing of lines across extensive pedigree charts. This has been illustrated in Figure 16*A*.

Twins

Twins have been represented by two symbols joined by diagonal lines converging to a common point on the fraternity line. Twins may be either identical or fraternal. For factorial analysis of sibships and for other reasons this information is important. It is therefore suggested that a symbolism be used which records this essential datum, as is shown in Figure 16*B*. Identical twins arose as a single zygote which later became split, and the symbol for twins now in use represents that situation admirably. Identical twins would be represented as symbols at the ends of two lines converging at the fraternity line (Figure 16 *B2*). Identical triplets would be represented by three converging lines, etc. Fraternal twins arise from two zygotes, and so would be represented as arising independently from the fraternity line just as siblings are (Figure 16 *B1*). Since they are born at the same time they are linked by two horizontal lines joining the symbols. This convention, (plus the fact that both twins are attached to the fraternity line), will avoid confusion with a marriage line. Ordi-

narily marriage of one or both twins can be shown without confusion. In Figure 16 *B3* is shown the representation of triplets made up of an identical twin pair of males and a sister born at the same time. In Figure 16 *B5* is shown a set of triplets derived from three eggs, hence arising from the fraternity line by three separate lines. If there is a question as to the zygosity of twins of the same sex, they might be represented as in Figure 16 *B4* with a question mark under the lines.

It might be objected that the representation in use, namely two symbols joined by converging lines, is sufficient, and the data supplied in the text will describe the type of twins. This is not always the case. Even in pedigrees prepared by competent geneticists this information is sometimes omitted from the text. The author knows of an instance wherein twins of the same sex were joined by the converging lines. Correspondence with the author revealed that the twins were definitely fraternal. If one has to use one or the other type of representation before one can put the twins into the pedigree, it brings to the fore the question of zygosity, making it more likely that all information will be recorded.

Twins in Factorial Analysis of Sibships

It is obvious that if one is studying the transmission of a trait which is hereditary, and is testing the goodness of fit between the data and theoretical expectation by means of the various methods of analysis which employ the binomial theorem, one will treat twins, or multiple births in general, differently if they are from one egg or from more than one. If they are from one egg, from the standpoint of the analysis the two or more individuals are treated as one person. If they are from two or more eggs, they are treated as two or more persons. If a group of families being examined had a large number of identical multiple births and if all twins were treated as two, and triplets as three persons, etc., the results would be in error, and the larger the number of identical twins in the series, the greater the error. In the extreme hypothetical example in Figure 16*B*, one sees twelve children represented, eight males and four females. One would expect only 12 per cent of 12-child families to show this sex distribution. Actually, only nine zygotes are represented, four of them female and five male, and the sex ratio is as near as possible to equality.

The same holds true in cases where a defect is being studied. If normal parents have one normal child and a pair of identical twins that are albinos, one cannot count that as a sibship of three with two affected, but as of two with one affected. Obviously the erroneous inclusion of identical twins as two persons, or of fraternal twins as one, would alter the accuracy of the conclusions.

Summary

It is desirable that in pictorial representations of genetic data, the idea expressed be set forth with as little confusion and as great clarity as possible: that standard symbols be capable of unequivocal interpretations, and that as much data be conveyed visually as is possible without confusion. New methods of representing products of conception that are lost before term, cousin marriages and twins are suggested.

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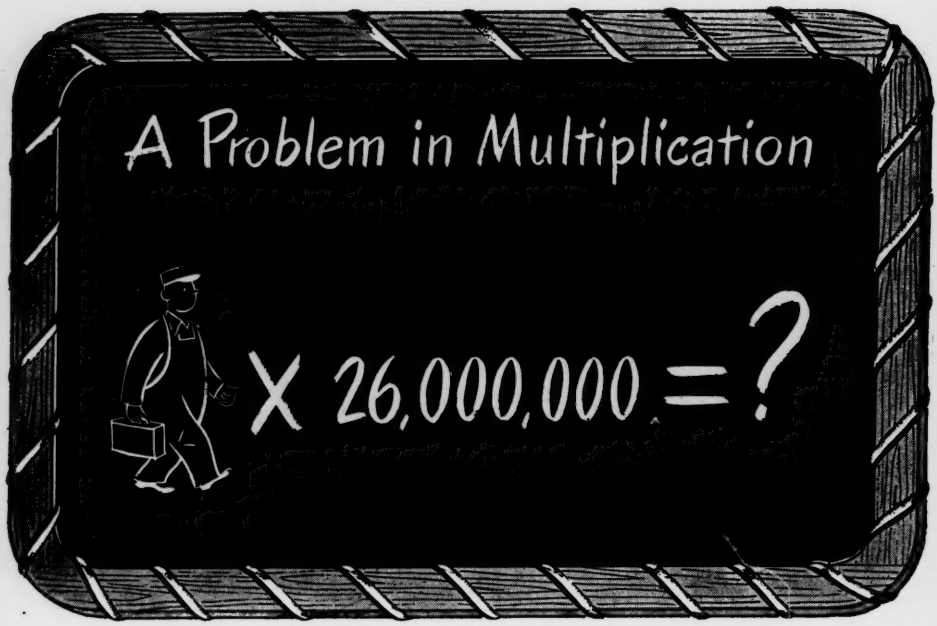

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